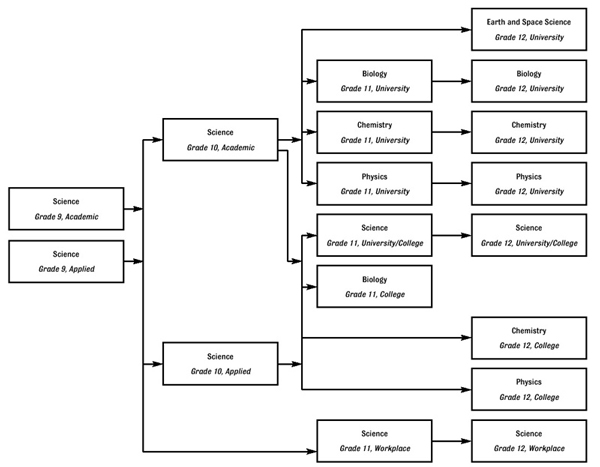
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| Summary: SPH4C – Grade 12 Physics |
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| Energy Transformations |

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**Background Knowledge**

Students arriving in the SPH4C will most likely have come through the Science Grade 10 Applied stream (See diagram below). Students entering SPH4C have had no recent formal curriculum based experience with the subject of energy transformations. It is not until SPH4C that the topic is covered in the secondary curriculum (SPH3U covers this topic but would likely not affect students in SPH4C). In fact you would have to go back to grade 5 science to find the last time most of the students in SPH4C covered the topic of Energy Transformations and the Conservation of Energy.



Prerequisite Chart for Science – Ontario Curriculum Document 2008 Revised

It would therefore be safe to conclude that there would be little or no direct background knowledge of this topic. It should then be assumed that most if not all concepts will have to be learned from first principal. Additionally, the curriculum expectations include a more qualitative examination of this topic so that any math skills needed for this topic should have been learned already.

**Specific Expectations Covered**

E2.1 use appropriate terminology related to energy and energy transformations, including, but not limited to: work, gravitational potential energy, kinetic energy, chemical energy, energy transformations, and efficiency [C]

E3.1 describe and compare various types of energy and energy transformations (e.g., transformations related to kinetic, sound, electric, chemical, potential, mechanical, nuclear, and thermal energy)

E3.2 explain the energy transformations in a system (e.g., a toy, an amusement park ride, a skydiver suspended from a parachute), using principles related to kinetic energy, gravitational potential energy, conservation of energy, and efficiency

**Lesson Sequence**

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| Lesson | Activities and Assessments |
| **Lesson 1**: Introduction - What is energy, how is it measured, and the various types of energy | 1. Conservation of Energy demo with bowling ball.  2. What is energy question (K/U, T/I)  3. Pencil dropped on floor activity (T/I, C)  4. Graphic Organizers for energy types (K/U, C) |
| **Lesson 2**: Energy Transformations and the Law of Conservation of Energy | 1. Explore Learning Gizmos Lab – Conservation of Energy in a Closed System (K/U, T/I, C) |
| **Lesson 3**: Energy Transformations and the Law of Conservation of Energy | 1. Conservation of Energy applied to real world examples - worksheet (C, A).  2. How Stuff Works roller coaster virtual lab dealing with potential and kinetic energy transformations. (T/I, C, A) |
| **Lesson 4**: Energy transformation myths and applications | 1. Myths questionnaire (T/I, C, A)  2. Application worksheet for real life energy transformation systems (C, A). |
| **Lesson 5**: Career connection, Applications and review if needed. | 1. Perpetual motion think-pair-share activity (T/I,A, C).  2. Youtube video on efficiency.  3. Career Connections activity |

**Lessons and Teaching Ideas**

**Lesson 1**

The idea that energy is transformed into other kinds of energy is not intuitive and most students would say that energy is “used up” or “lost”. The Bowling ball or other heavy object swinging back and forth provides a visual for the fact that energy is:

* Conserved
* Transformed back and forth between potential and kinetic energy
* Somehow decreasing as the ball’s displacement gets smaller and smaller.

The idea with this is to introduce the students to these ideas in a fun and somewhat daring way. Following the Demo (either physical or virtual – see website below) do a think-pair-share on why the bowling ball did not hit the student or teacher.

<http://science.howstuffworks.com/engineering/structural/roller-coaster3.htm>

**Safety**

When attaching heavy objects and swinging them in the class caution must be exercised. Ensure the ceiling is made to support such a load swinging, and provide detailed instructions to students willing to participate with regards to leaning forward, pushing the ball (a definite no-no), and the right to duck out of the way if they feel uncomfortable.

**Definition of Energy:**

Ask the students what they think energy is. Expect lots of examples of energy and perhaps an answer stating that energy is a physical quantity and that it can be measured. Generally the term energy is confused with the idea of work in which case the students are really thinking of the result of energy transforming and in the process work is being done. Energy is rarely measured directly but its ability to do work allows us to quantify it through the measure of how much work it can do.

*Energy transformation* is the changing of one kind of energy into another kind of energy

*Energy* is the measure of that “thing” that allows a system to do work.

Stated another way: *Energy* allows a machine or system to do some kind of work.

So when we speak of the measurement of energy we are really measuring how much work can be done by the system in question.

At this point students may ask what work is. Work and energy appear to be interchangeable but they are not (although they use the same units). Work is what gets done to an object by a force and Energy is what allows it to happen (sort of like the currency in a transaction).

**Measurement Units**

The SI unit of energy is the joule (J) or newton-meter (N \* m).

The measurement of energy, no matter what form it is in, can always be stated using Joules alone or Joules in conjunction with other units (e.g. Heat Capacity which is J/kg.K). Therefore the measurement of energy (no matter what form) is always related to the idea of how much work the system could do using standard units of joules measured in Newton-meters (Nm).

This is convenient and makes it easier for the students to understand transformations where X number of joules of energy transforms into X number of joules of energy in a different form. Work is also measured in joules which makes it confusing if students do not understand their definitions.

**Types of Energy**

Kinetic Energy – Energy of Motion

Mechanical Energy — motion of macroscopic systems: (machines, wind energy, wave energy, sound (sonic, acoustic) energy

Thermal Energy- motion of particles of matter: (geothermal energy)

Electrical Energy — motion of charges (household current, lightning)

Electromagnetic Radiation — disturbance of electric and magnetic fields [classical physics] or the motion of photons [quantum physics]: (radio, microwaves, light including infrared, ultraviolet, x-rays, gamma rays, solar energy

Potential Energy – Energy of Position

Gravitational Potential Energy – (roller coaster, waterwheel, hydroelectric power)

Electromagnetic Potential Energy – (electric potential energy, magnetic potential energy)

Chemical Potential Energy – (Batteries, fossil fuels, food)

Elastic Potential Energy – (Elastics, metal springs, bungee cords)

**Lesson 2**

Law of Conservation of Energy states that energy is neither created nor destroyed but it can transform into other forms. Therefore the total energy of an isolated system remains constant. This concept of the conservation of energy is sometimes referred to as *The First Law of Thermodynamics.*

Thus, the total energy of an isolated system is always constant and when energy of one form is expended an equal amount of energy in another form is produced. Use the following Virtual Lab to illustrate the conservation of energy in a closed system (K/U, T/I, C). This experiment is similar to Joule’s famous experiment described below.

<http://www.explorelearning.com/index.cfm?method=cResource.dspView&ResourceID=416&ClassID=0> - A Gizmo that illustrates the transformation of kinetic energy into thermal energy.

“In 1845, Joule performed an experiment that demonstrated energy transformation both qualitatively and quantitatively. The experiment was not complicated--he placed a paddle wheel in a tank of water and measured the temperature of the water. He then cranked the wheel in the water for a period of time, and read the temperature again. He found that the temperature of the water rose as he cranked the paddle wheel. He quantified this observation and discovered that an equal amount of energy was always required to raise the temperature of the water by one degree. He also discovered that it did not have to be mechanical energy; it could be energy in any form. He obtained the same results with electrical or magnetic energy as he did with mechanical energy. Joule's experiments showed that different forms of energy are equivalent and can be converted from one form to another.”

Joule’s experiments were revolutionary for their time and the thought that heat could be created somehow by some other energy was considered unscientific and stood in direct defiance to the old *caloric* theory which stated that **heat** could not be created or destroyed. In fact it is energy that cannot be created or destroyed. If we incorporate Einstein’s thinking and nuclear reactions then we must state that the **energy/mass** duality is never created or destroyed but this concept is beyond the SPH4C curriculum.

**Lesson 3**

Energy can transform from one form into another form. The students have been exposed to some of this already but we now take it to a more complex level and we reverse the process to practise thinking and application. Here the students are given the energy transformations and they have to determine what device would produce them. Have the students give examples for each of the sample transformations. Groups work well with this exercise and the students can think of their own samples as well. (C, A)

* Electrical energy into sound and light energy. (television)
* Electrical energy into thermal energy and light. (toaster)
* Chemical energy from fuel into thermal energy and mechanical energy. (car)
* Chemical energy from batteries into light energy. (flashlight)
* Light energy into electrical energy. (solar panels)
* Chemical energy stored in wood into thermal energy. (fire)
* Gravitational energy into electrical energy. (hydroelectricity)

**Transfer of Potential to Kinetic and Kinetic to Potential**

Students should understand the following formula in a qualitative sense.

KEinitial + PEinitial + Wexternal = KEfinal + PEfinal

*Wexternal* is the transformation of kinetic energy into heat (friction of wheels, wind, etc.) It works against the forward motion of the roller coaster and would be negative.

Use the Roller Coaster lab below to illustrate how energy transfers back and forth in a system (scroll down on the web page to play). Have students measure, record and graph the amount and type of energy levels at each stoppage. (T/I, C, A)

<http://science.howstuffworks.com/engineering/structural/roller-coaster3.htm> - Roller Coaster Ride showing how kinetic and potential energies transform into each other.

**Lesson 4**

The following is a great assessment of learning chance. Have the students write true or false after each of these and why they think it is so. Later use a whole class discussion to examine them. (T/I, C, A)

**Myths**

1. Energy is truly lost in many energy transformations.
2. If energy is conserved, then we should not be running out of it.
3. Things “use up” energy.

**Myth #1.**

*Energy is truly lost in many energy transformations.*

Fact: Energy is never created or destroyed (except in nuclear reactions where it is transformed from matter into energy according to Einstein's famous E=MC^2).

Sometimes it appears as if energy is disappearing but upon closer examination “hidden” systems of energy transformations will always be found.

**Myth #2**

*If energy is conserved, then we should not be running out of it.*

Fact: Even though energy is never destroyed, we usually complain that the world is suffering from an energy shortage. Indeed we are suffering from shortage of high-grade energy that has the potential of producing useful work. In every energy conversion, some high-grade energy is converted into low-grade energy as heat.

**Myth # 3**

*Things “use up” energy.*

Fact: Systems and machines do not use up energy. Rather they convert or transform energy from one form into another form.

The following examples can be used to practice determining what energy transformations occur: (C, A)

* Lightning a match e.g. (chemical → thermal and light)
* The cycle of energy from the sun ending up as growing plants
* A hydroelectric station
* A hair dryer
* A refrigerator
* The formation of coal and oil
* Turning on a flashlight
* Fireworks displays
* Getting to school in the morning!

The more complex examples in the list above could also be used as a culminating task. Students would breakdown each system into its constituent energy transformations and produce the following: (A, C, T/I, K/U).

* Proper listing of all energy transformations
* Listing of whether each transformation results in useful work done. If it did not result in work done then where did it go and what did it transform into?
* The method you might use to measure the energy at each stage.

**Lesson 5**

Introduce the idea of a perpetual motion machine. Do a think-pair-share on why it could or could not work. Have pairs double up and act out their best perpetual motion idea (T/I, A, C). This should lead into a discussion on efficiency.

Efficiency – The efficiency of a system or machine is the measure of how much energy is transformed into types of energies that can do no work. No transformation is 100% but the closer it is the more efficient the machine or system is. Watch the following video for more info.

<http://www.youtube.com/watch?v=3QiLlc9QMU8>

The idea of maximizing energy transformation efficiency is part of everyone’s job on daily basis even if it is only a maximizing of your own energy transformations. However in some professions maximizing efficiency is central to their job. Some examples include:

1. Engineering
2. Environmental Consultants
3. Architecture
4. Government (ministries that deal with power, the environment, finances)
5. Renewable energy industry

In groups students can pick one area above and research how energy efficiency might be part of jobs in that field. (STSE)

**Instructional Strategies for ELL and IEP**

* Review labs on SMART board prior to the actual lab and invite all questions
* Supply handouts or online material for sessions that are more verbal
* Practice scientific literacy skill building by reviewing new words and methods of displaying information (e.g. bar graphs on the Roller Coaster lab)
* Emphasize team and partner work
* Provide exemplars for lab work
* Utilize assessment AS learning throughout
* Provide adequate/extra time for reading and assignments

**Annotated References**

<http://www.explorelearning.com/> - Explore Learning

<http://www.howstuffworks.com/> - 1998-2011 HowStuffWorks Inc.

<http://en.wikipedia.org/wiki/Energy_transformation> Wikipedia Foundation Inc.

<http://www.physicsclassroom.com/mmedia/energy/ce.cfm> - 1996-2011 The Physics Classroom

<http://www.bookrags.com/research/energy-transformations-woc/> -2011 by BookRags, Inc.

<http://www.youtube.com/> - 2011 YouTube, LLC

<http://www.enotes.com/energy-transformations-reference/energy-transformations> - 2011 eNotes.com, Inc

<http://telstar.ote.cmu.edu/environ/m3/s3/all_ene_sys.htm> - Copyright 2003 Carnegie Mellon University